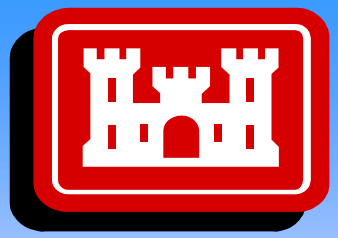
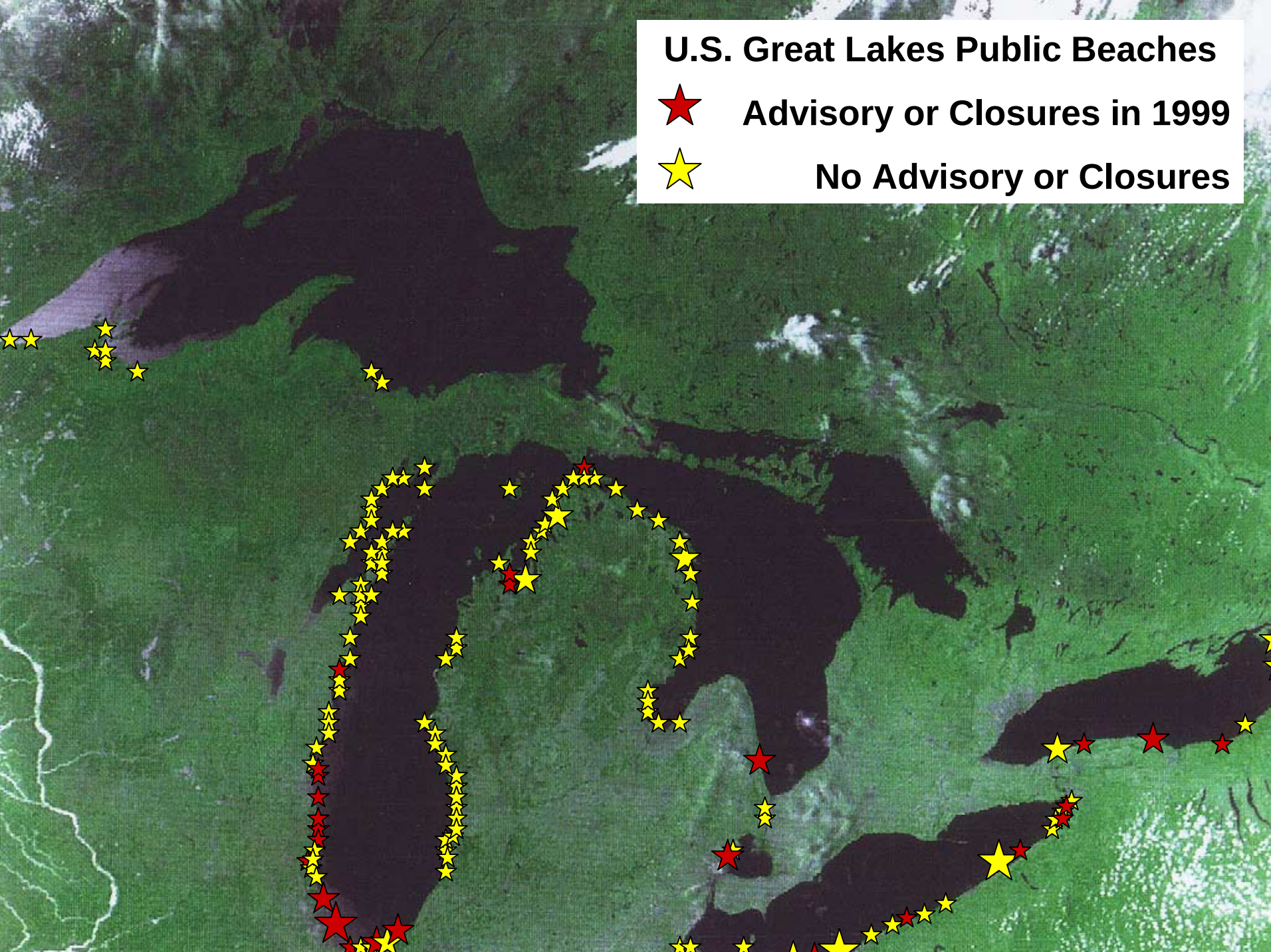


U.S. ARMY
CORPS OF ENGINEERS
DETROIT DISTRICT

Physical Processes Affecting Beach Use

Roger L. Gauthier
Great Lakes Hydraulics and Hydrology Office

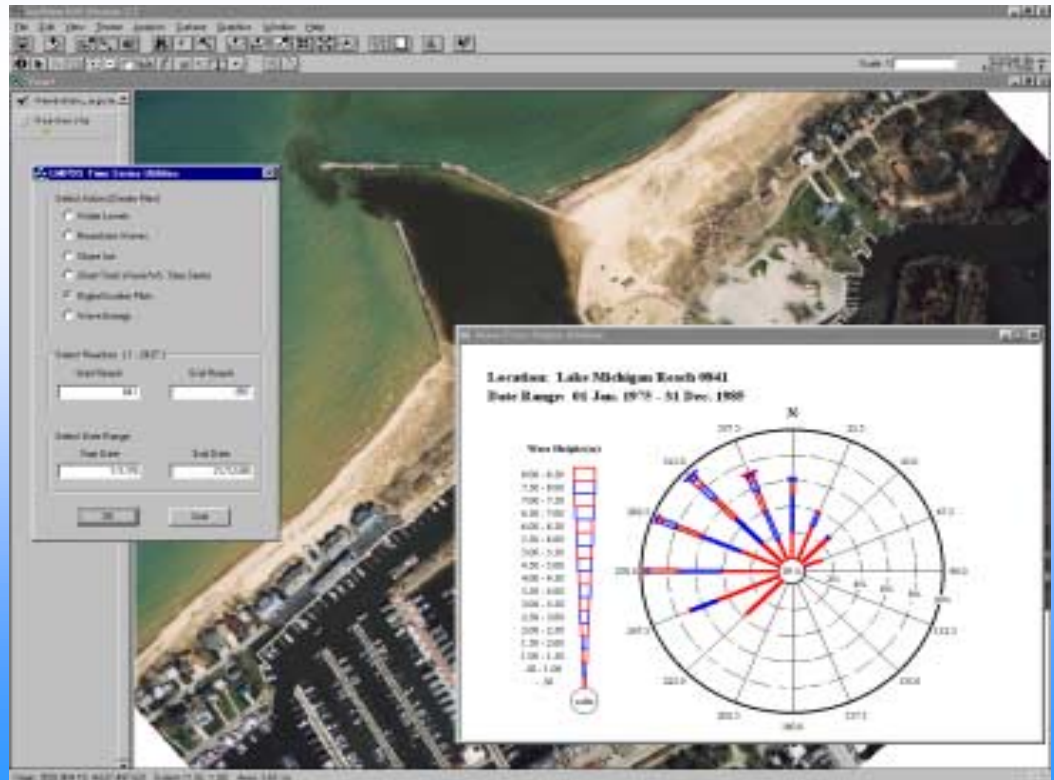
Presented at the
2001 Great Lakes Beach Conference

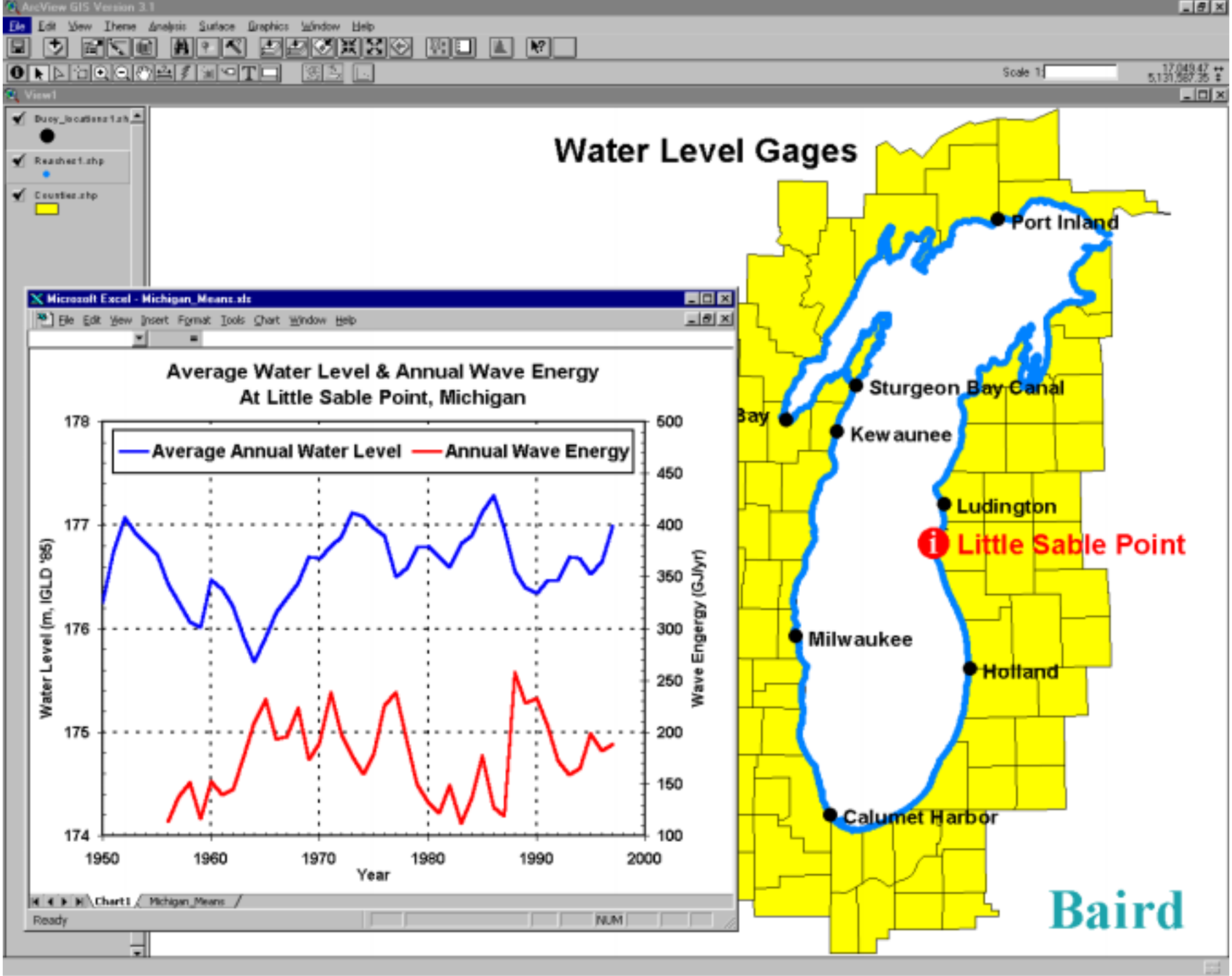

U.S. Great Lakes Public Beaches
Advisory or Closures in 1999
No Advisory or Closures

Effects of Water Level Fluctuations - Localized Disturbances

- Wind and waves
  - Cause local rise / fall of levels by .5 meters
  - Barometric pressure surges occur over hourly to weekly time scales

- Storm dynamics - can rapidly change surface water current patterns and nearshore mixing

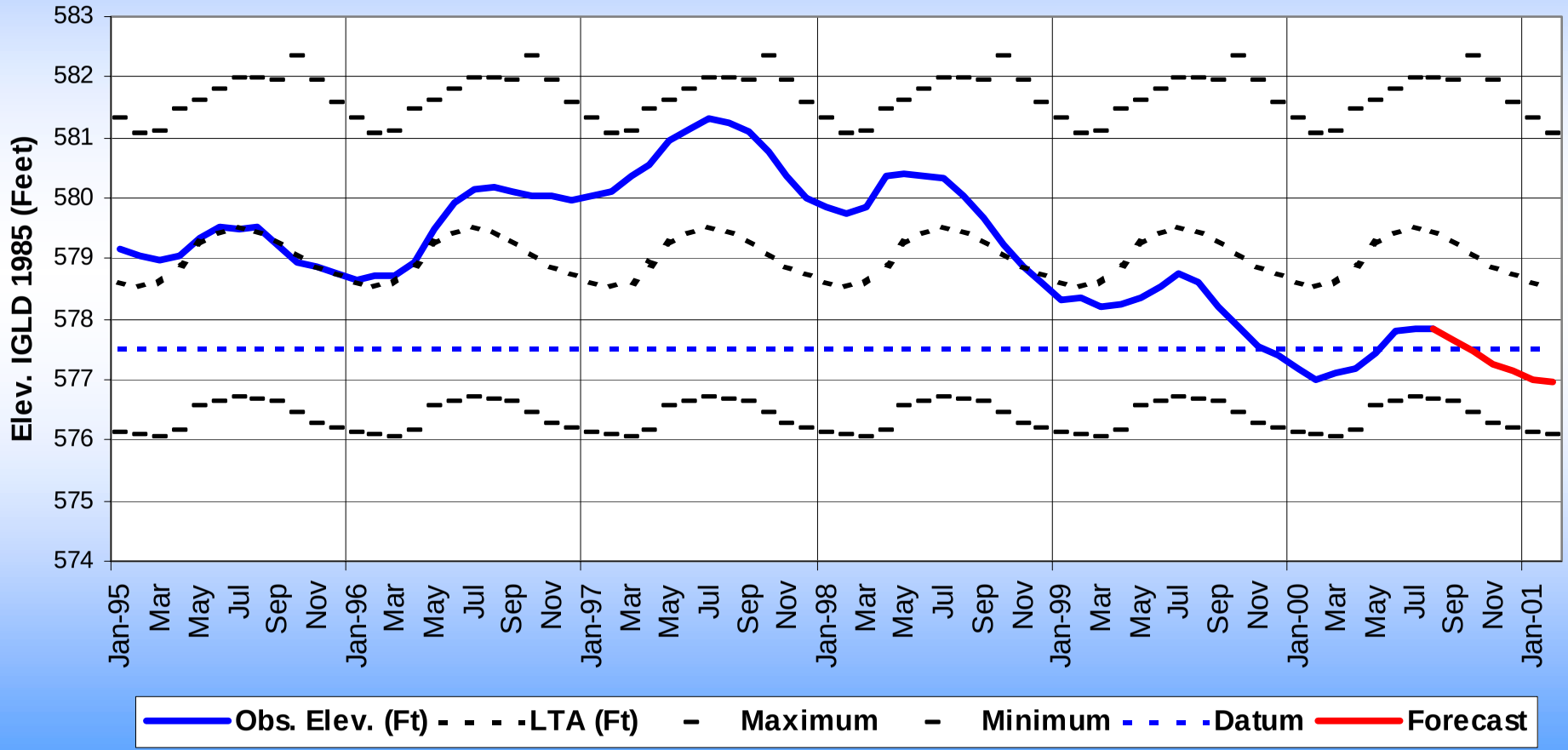


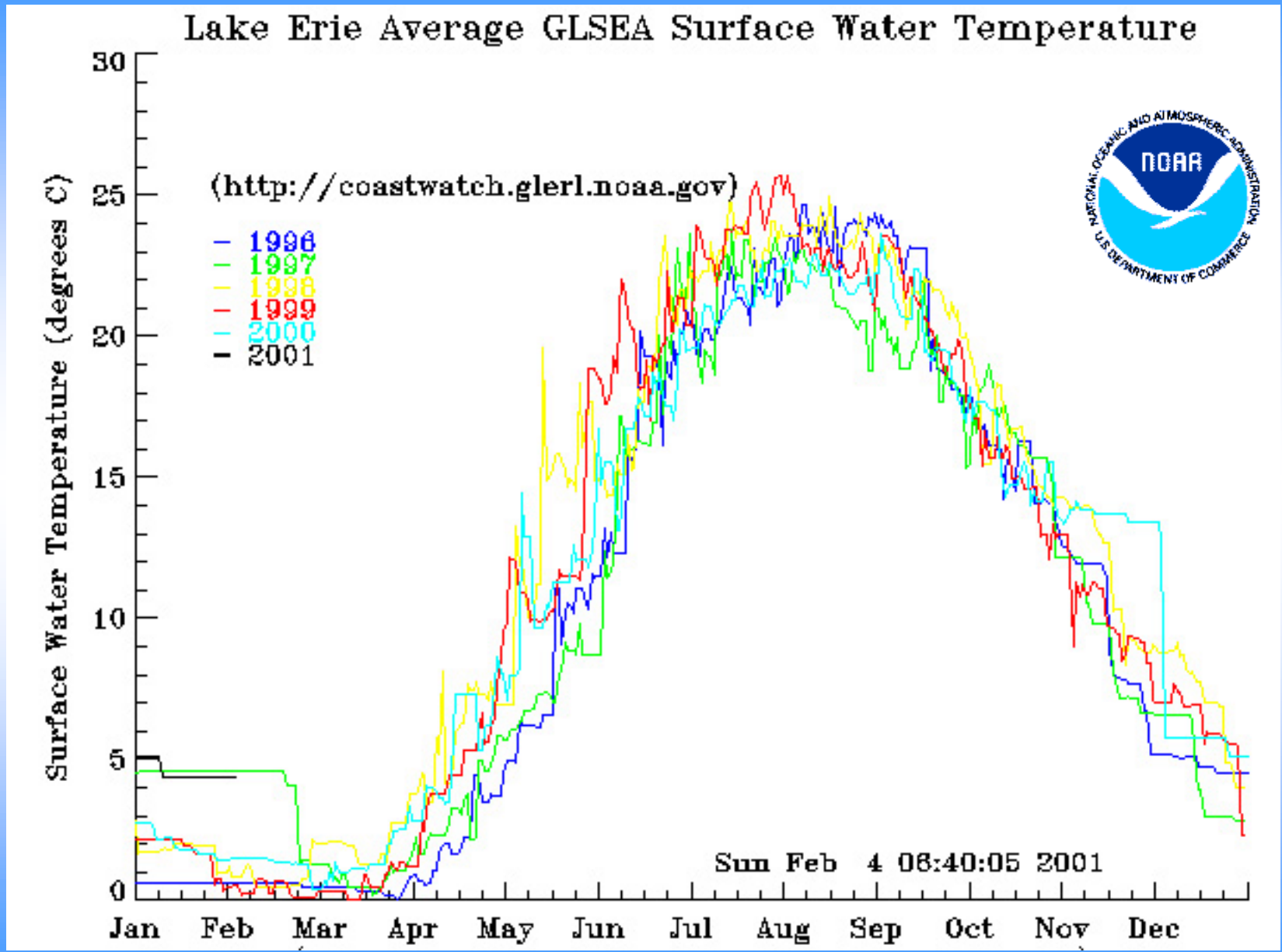

Water Level Gages
Port Inland
Sturgeon Bay Canal
Kewaunee
Ludington
Little Sable Point
Milwaukee
Holland
Calumet Harbor
Baird
Microsoft Excel - Michigan_Means.xls
Average Water Level & Annual Wave Energy
At Little Sable Point, Michigan
Average Annual Water Level
Annual Wave Energy
Water Level (m, IGLD '85)
Wave Engergy (GJ/yr)
Year
178
177
176
175
174
500
450
400
350
300
250
200
150
100
1950
1960
1970
1980
1990
2000
Chart1
Michigan_Means
Ready
NUM

Effects of Water Level Fluctuations - Seasonality

- Spring/Summer Rises
  - Seasonal rises average .3 meter on all lakes
- Drought Conditions
  - Currently normal rises occur several weeks earlier
- Wet Weather Conditions
  - Lakes rise .3 meters above average with sustained wet weather conditions
- Summer Peaks
  - Lakes peak on average during early to mid-summer

Lakes Michigan – Huron Water Levels 1995 -2000

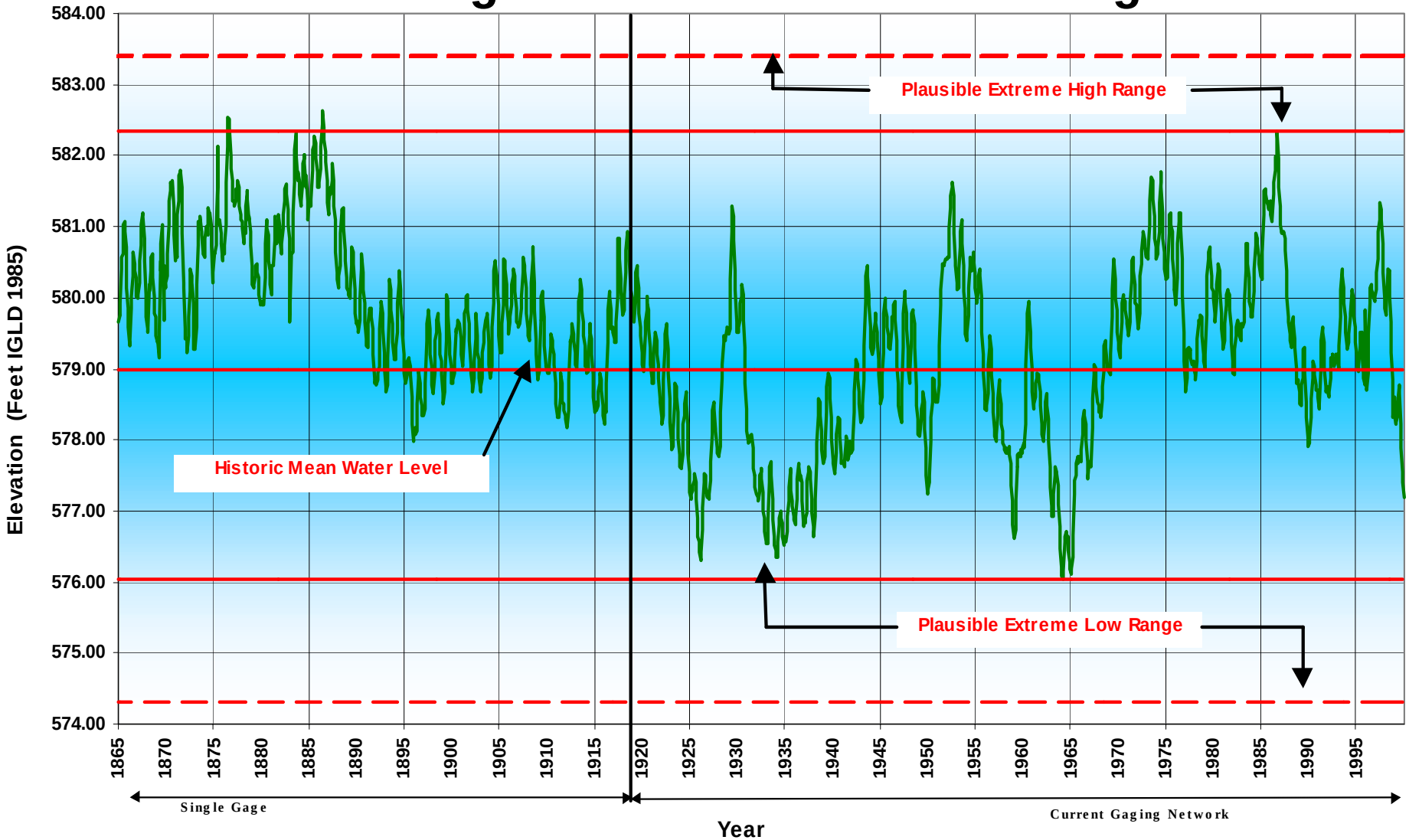



Lake Erie Average GLSEA Surface Water Temperature
(http://coastwatch.glerl.noaa.gov)
1996
1997
1998
1999
2000
2001
Surface Water Temperature (degrees C)
0
5
10
15
20
25
30
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Sun Feb 4 06:40:05 2001
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

Effects of Water Level Fluctuations - Climatic Variability

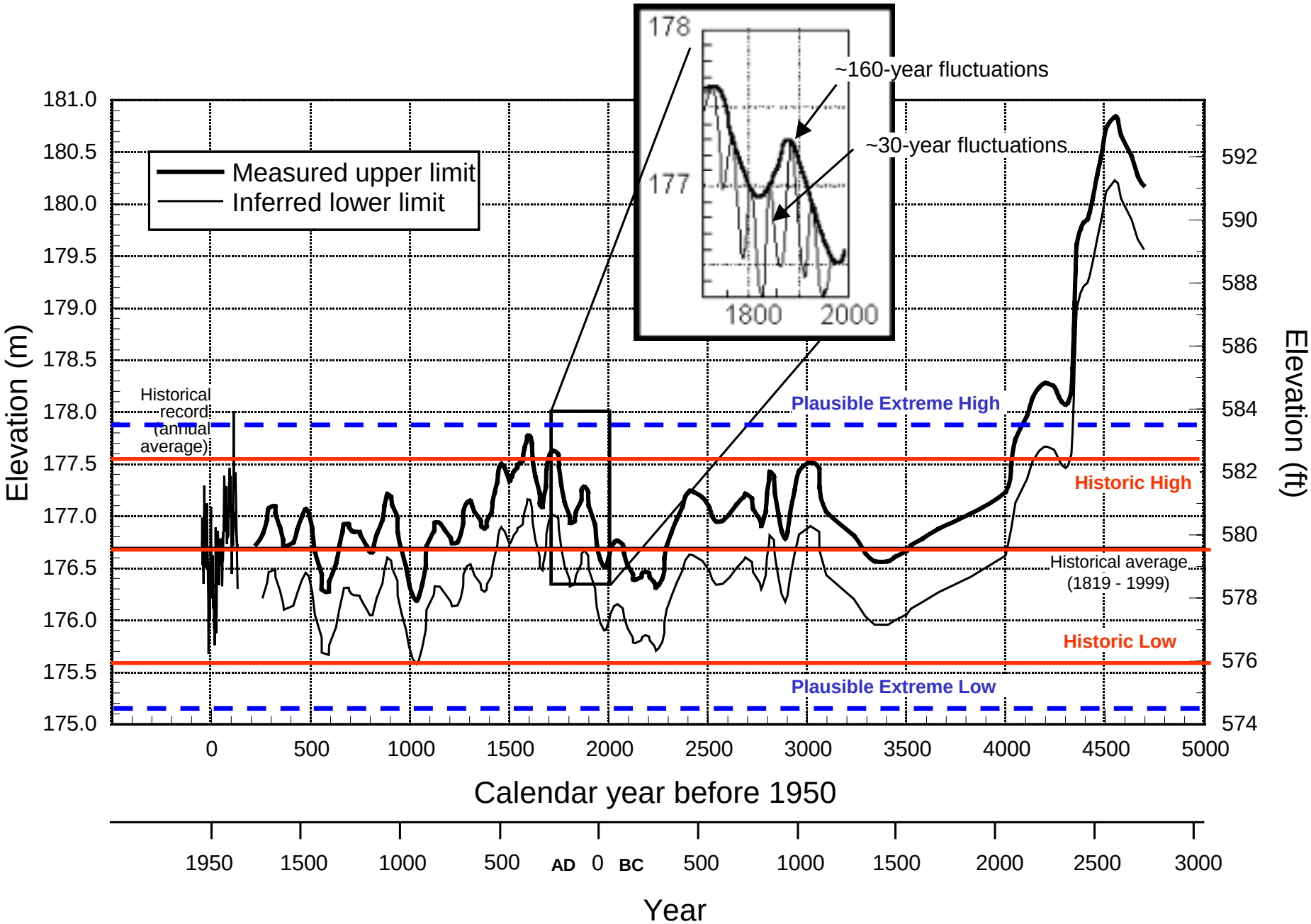
- Quasi-periodicity of extreme highs and lows on each of the lakes
- Short-term decadal shifts in water level regimes
- Historic ranges for most lakes near 2.2 meters
- Plausible extremes for most lakes near 3.0 meters

Lakes Michigan-Huron Water Level Ranges



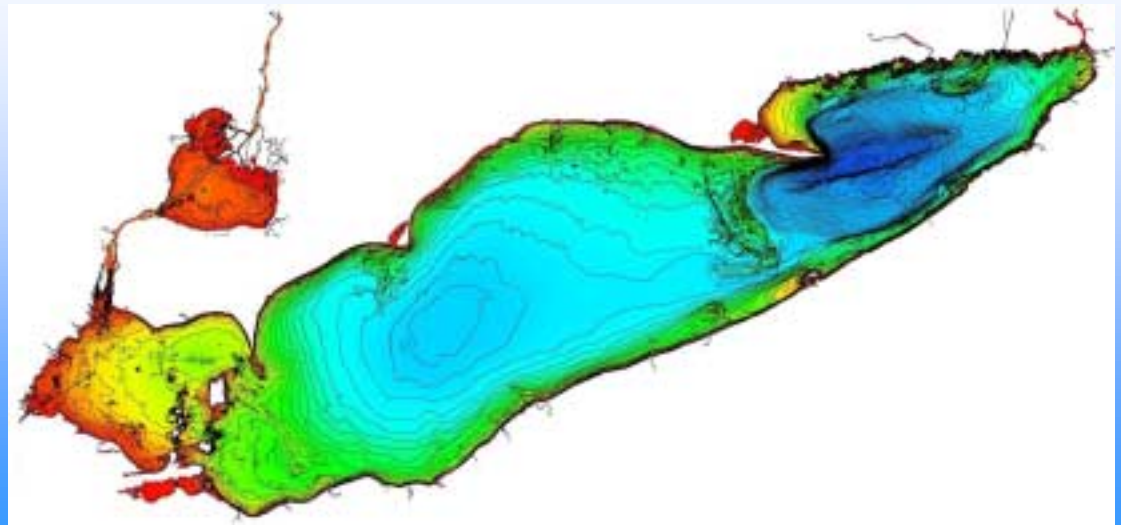
Effects of Water Level Fluctuations - Global Warming

- Projected lowering of lake levels by up to 1.5 meters below current range
- Projected increases in storm frequencies and intensities
- Significant changes in ice formation
- Projected warmer lake temperatures more conducive to bacteriologic contamination
- Substantial changes in circulation patterns and nearshore mixing


178
177
1800
2000
~160-year fluctuations
~30-year fluctuations
Measured upper limit
Inferred lower limit
Historical record (annual average)
Plausible Extreme High
Historic High
Historical average (1819 - 1999)
Historic Low
Plausible Extreme Low
Elevation (m)
Elevation (ft)
181.0
180.5
180.0
179.5
179.0
178.5
178.0
177.5
177.0
176.5
176.0
175.5
175.0
592
590
588
586
584
582
580
578
576
574
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Calendar year before 1950
1950
1500
1000
500
AD
0
BC
500
1000
1500
2000
2500
3000
Year

Effects of Changes in Lake Circulation Patterns

- Nearshore mixing highly variable depending on current patterns, waves, winds and barometric pressure changes
- Lake St. Clair eddies typify complexity of changes of nearshore circulation patterns



Lake St. Clair Turbidity Pattern

EEGLE

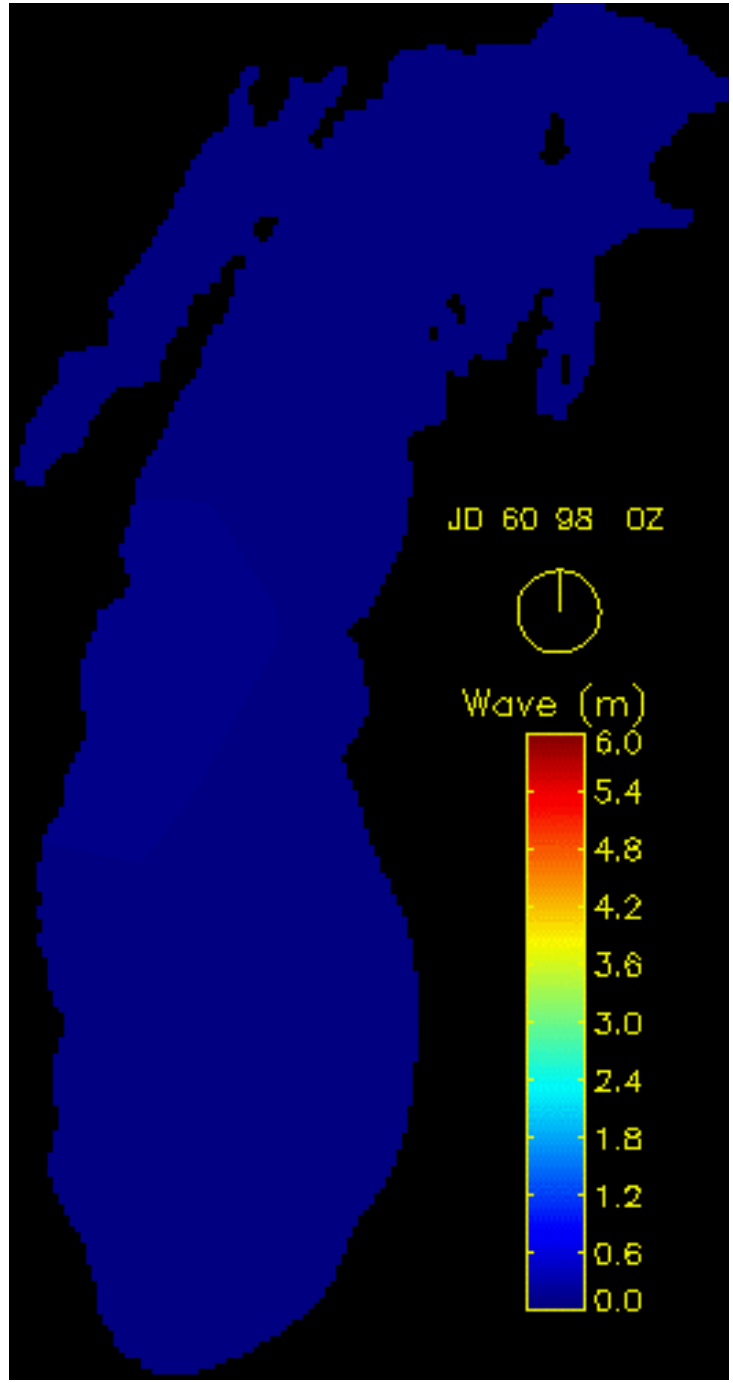
Episodic Events

Great Lakes

Experiment

March 1998

Modeled Significant Wave Heights



EEGLE

Episodic Events

Great Lakes

Experiment

NSF

NOAA

March 1998

Modeled Particle Trajectories

EEGLE

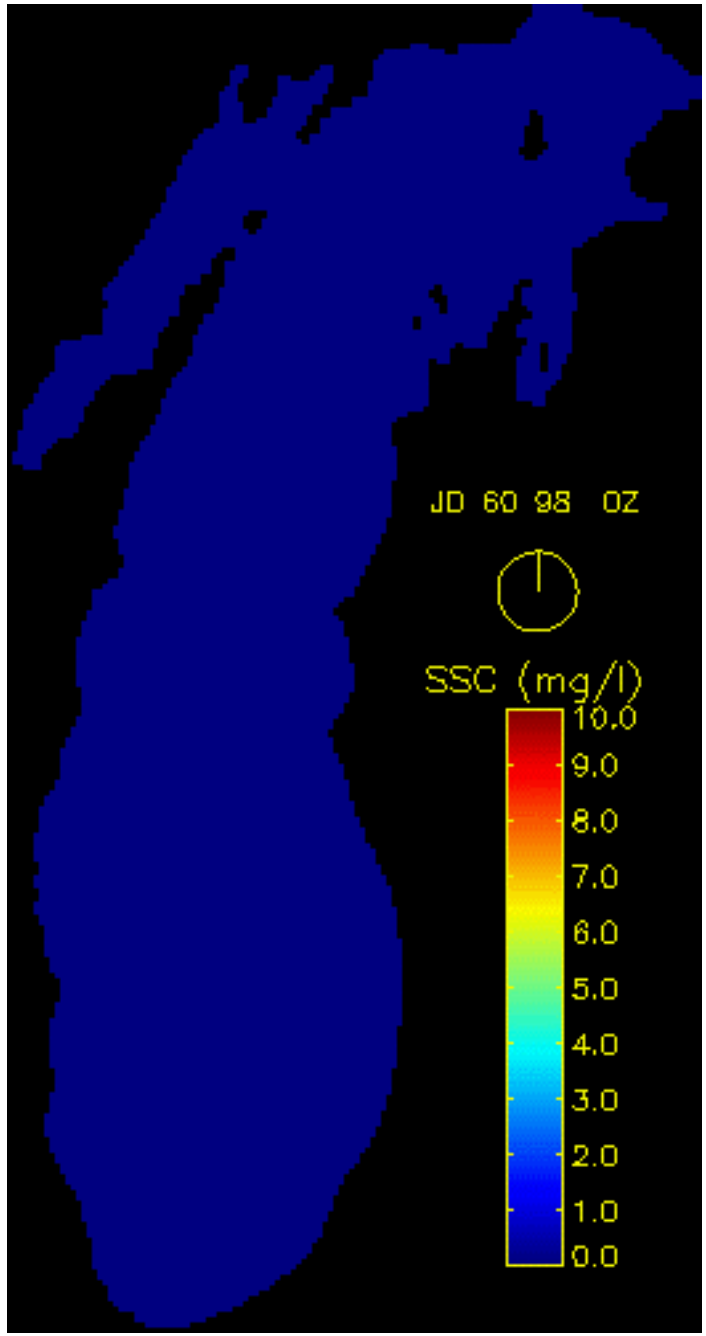
Episodic Events

Great Lakes

Experiment

March 1998

Modeled Surface Suspended Sediment Concentration



EEGLE

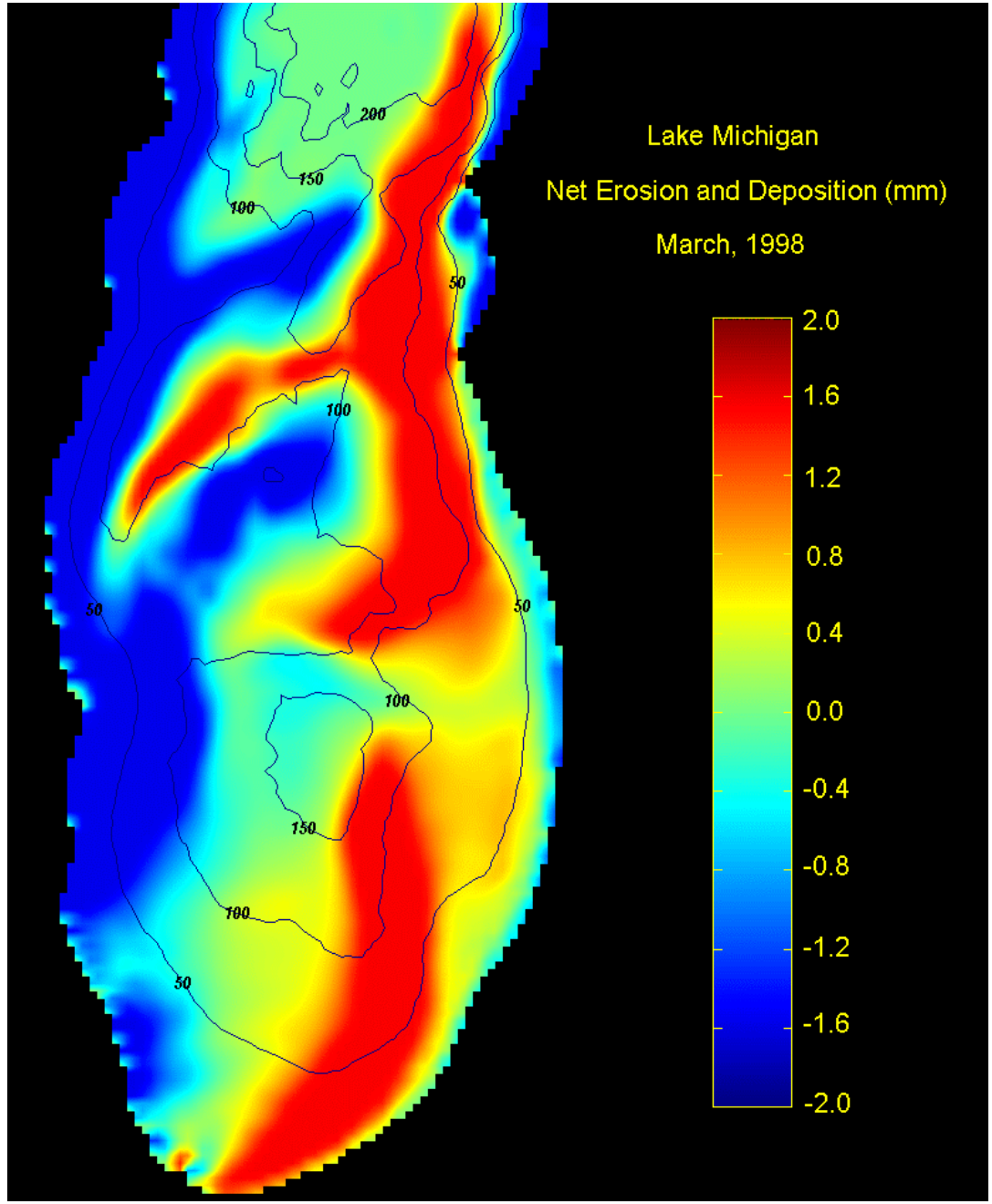
Episodic Events Great Lakes Experiment

NSF

NOAA

March 1998

Net Sediment Erosion or Deposition



Decaying Macrophytes, Carcasses and Litter

- Winds, waves, nearshore current pattens and ice conditions all affect the transport of organic material near beaches and the eventual decay

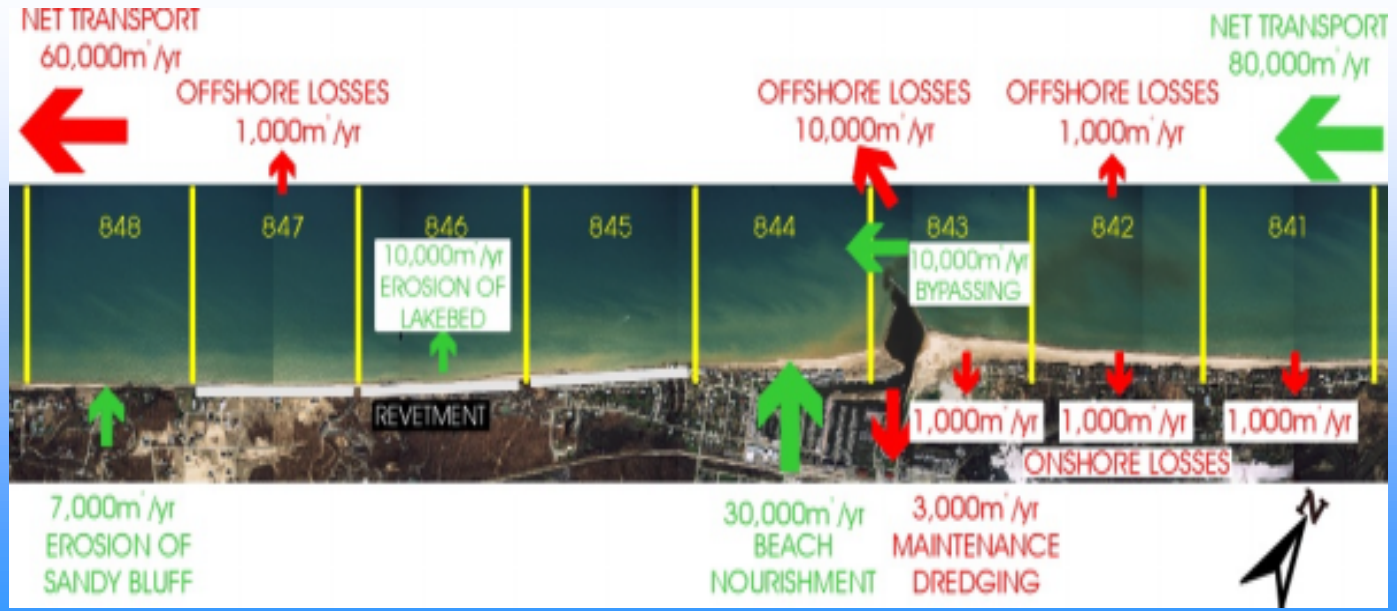
- Lower lake levels and reduced circulation patterns accentuated these problems

Effects of Changes in Sediment Transport

- On-shore / off-shore Sediment Transport
  - Cross-parallel beach processes are affected by wave dynamics, water levels, sediment supply and current patterns
- Alongshore Sediment Transport
  - Shore parallel transport highly affected by updrift sediment sources

Effects of Hardening of Shorelines

- Reduced sediment supply
- Drastically reduces beach sand cover
- Greater fraction of alongshore sediment transport lost to off-shore processes



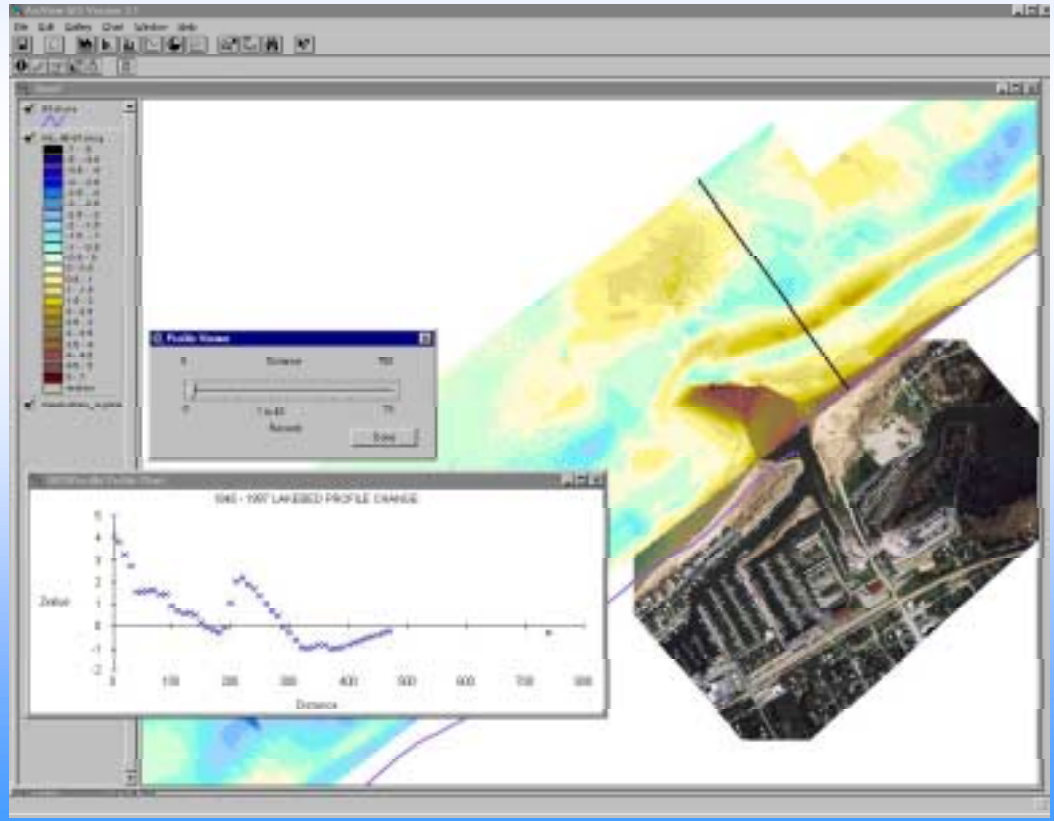
Grosse Pointe Yacht Club, MI Updrift Accretion

1937

1988

Beach Morphology

- **Highly affected by water level regimes**
- **Highly affected by protection of sediment sources**
- **Affected by beach nourishment activities**
- **Affected by decomposition of zebra mussel shells**



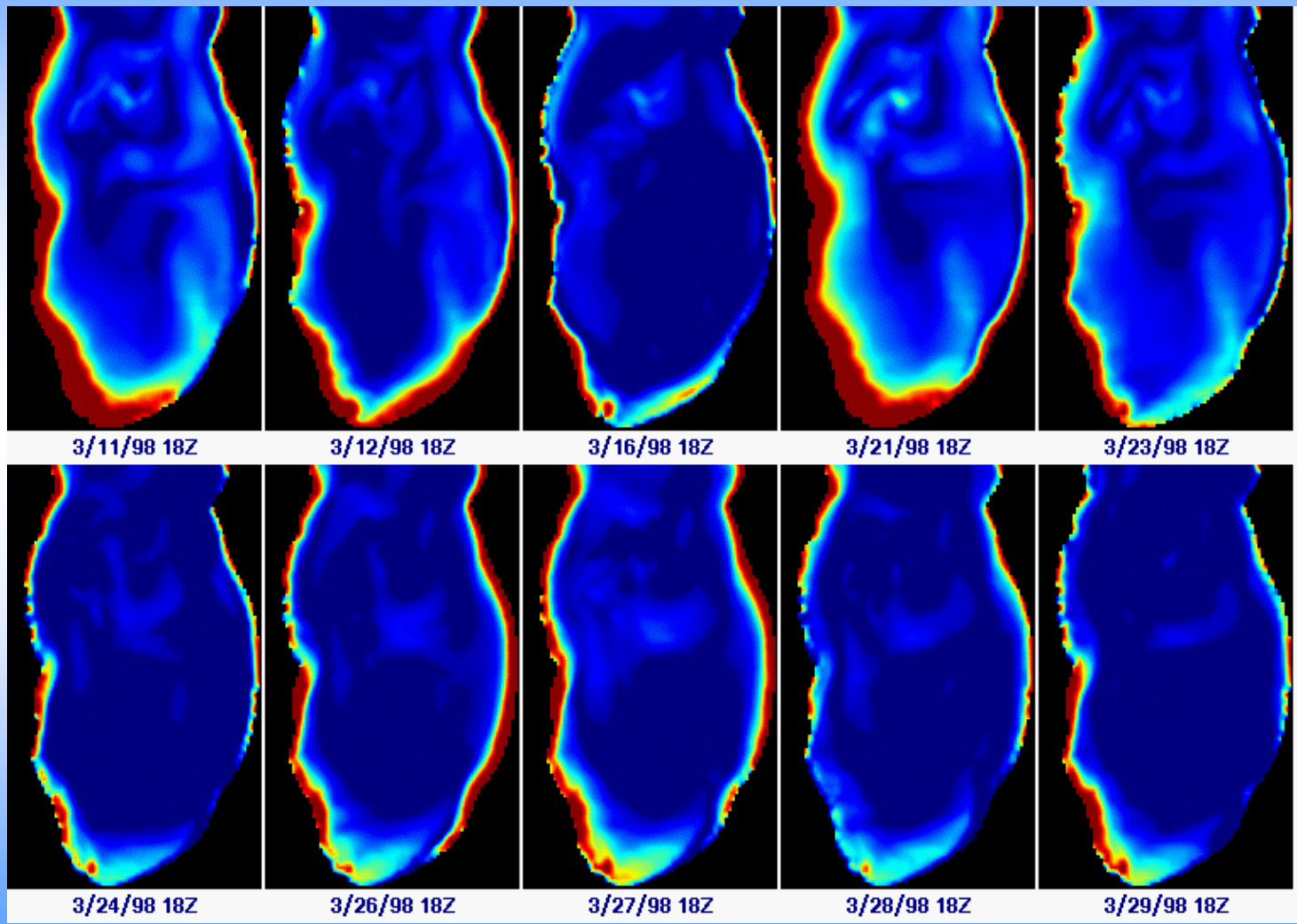
Changing Demographics

- Increased use of northern beaches
- Nearshore land use changes from rural or agricultural uses to residential and other built-up uses will decrease sediment supply and increase prospects for bacteriologic contamination
- Global warming will accelerate demand for beach use particularly further north

Breakout Discussion Topics

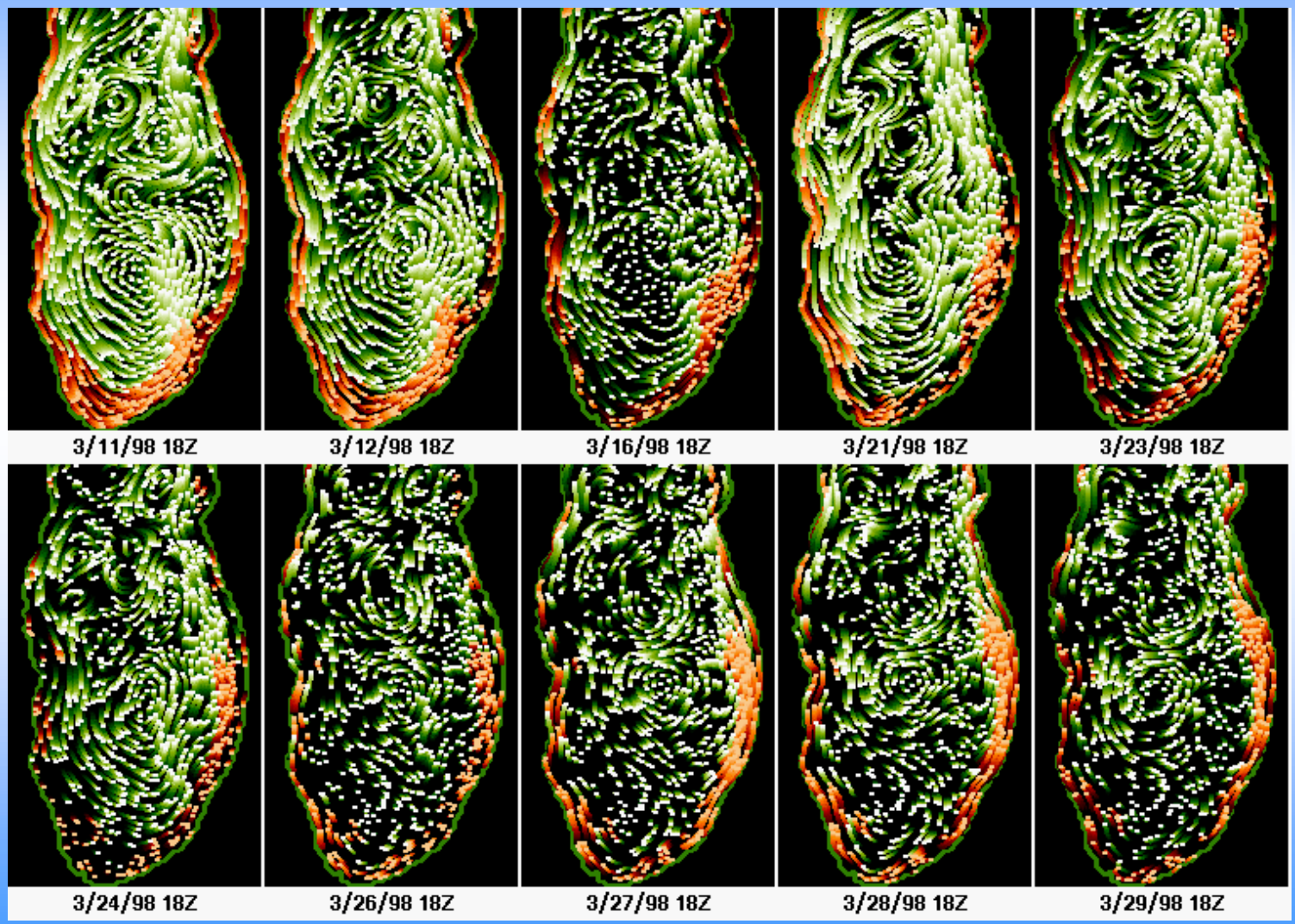
- Adequacy of short-term storm forecasting?
- Adequacy of nearshore circulation data and modeling
- Future sediment supply and shoreline hardening
- Effects of prospective long-term water level lowering

Episodic Events - Great Lakes Experiment



March 1998 - Suspended Sediment Concentrations

Episodic Events - Great Lakes Experiment



March 1998 - Particle Trajectory Animations

Great Lakes Bathymetry